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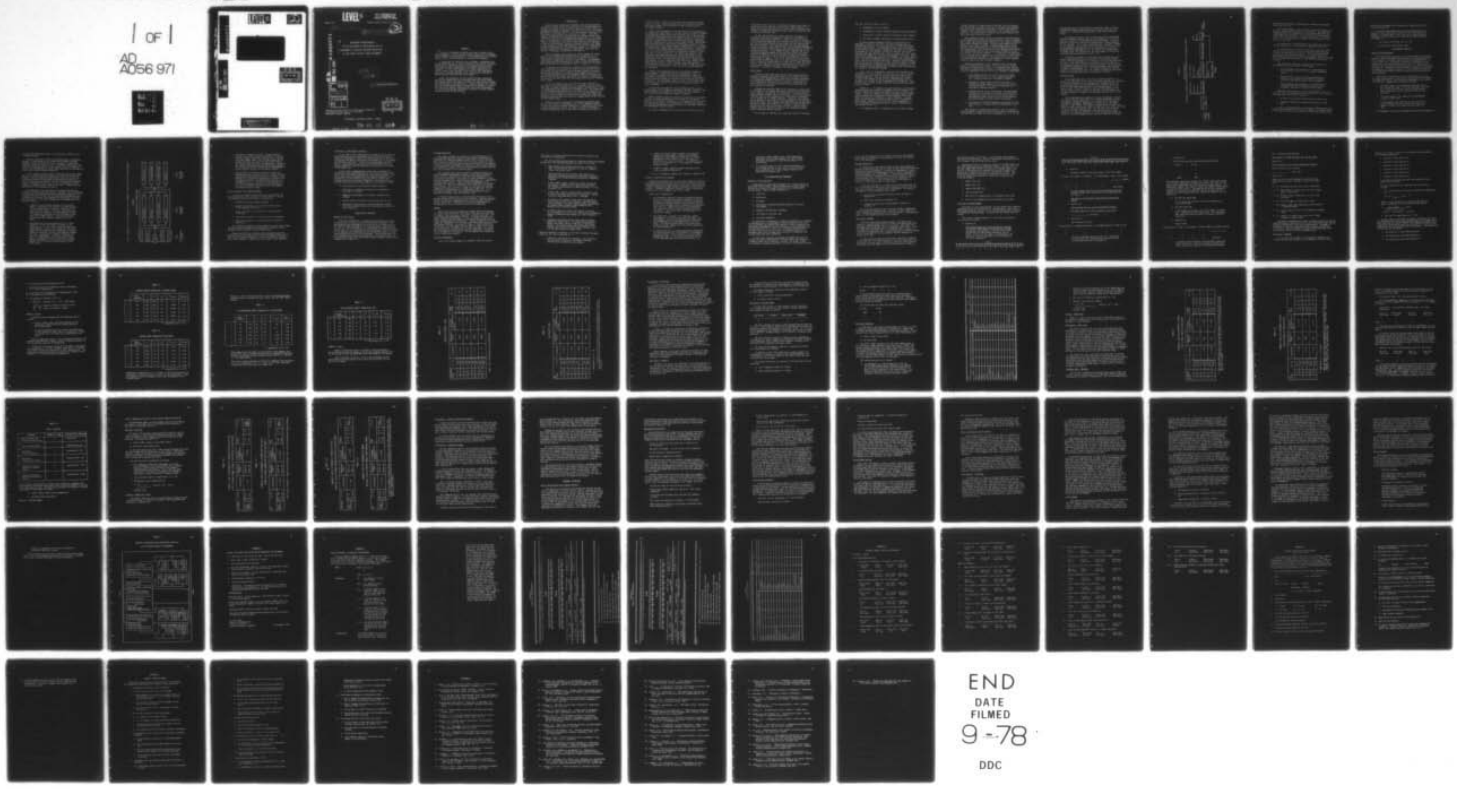

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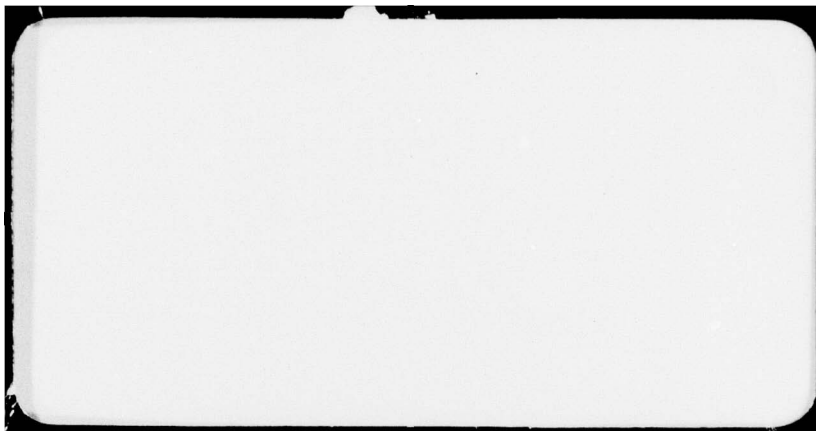

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INSTRUMENTS AND METHODOLOGY FOR THE ASSESSMENT OF PHYSIOLOGICAL COST OF PERFORMANCE IN STRESSFUL CONTINUOUS OPERATIONS - THE AIR TRAFFIC SERVICES TOWER ENVIRONMENT.

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ABSTRACT

A total of 39 females and males were used as subjects in a study designed to test the general validity and utility of methods and instruments of potential use in the determination of the physiological cost of work performance in stressful environments.

A second goal of the study was to attempt a preliminary test of the hypothesis that a form of employment (Air Traffic Services) traditionally considered stressful, was significantly different from general forms of employment traditionally considered less stressful. To test this hypothesis 23 people employed as air traffic control tower personnel were slated as the experimental group and 16 subjects employed in an operationally oriented research facility served as the Control group.

Within the parameters of this research design, consistent statistical significance was established when the entire sample was recategorized on the basis of subjective sleep adequacy assessment rather than by job description. Further research is indicated with well defined physiological categorization measures to obtain more definitive answers concerning job stress and physiological cost and the methodology development necessary to support general research efforts in this field.

INTRODUCTION

Within the past decade much information has become available concerning problems arising in connections with the performance of the hman sub-system in the extremely complex Air Traffic Services Man/Machine Systems environment. Some of the literature is strongly emotional in character, some of it is observational in nature, and the majority is scientific or technical in content. This wide range of information and conjecture has not always provided clear solutions to perceived or deomonstrated problems and it is evident that a restructuring of the systems philosophy for research is required. In addition to the difficulties caused by the complexity of the ATS system itself, the major research problem is the human in that system. With the human being in the system is associated a genetic predisposition; the behavioural effect of a lifetime of myth and morality and an exquisite individuality that make "the person" a challenge to quantifiable description.

There is evidence that unrealistic output demands are being made on the ATS human sub-system and that, in addition, it is believed that an increase of controller responsibility will no longer mean a commensurate increase in Air Safety. Knowledgeable people feel that we have arrived at a point in ATS function where more information and responsibility must be relegated to the pilot.

In contrast to the relatively rigidly structured and powerfully standardized environment in which the pilot functions as the sub-system, the ATS control tower environment displays no strong measure of uniformity in its design, which suggests that much of the information gained in any environmental study research project may be site specific rather than solely job specific. Within such restriction, this paper and other observation and interview findings must be read.

It has been suggested by some that ATS needs a miracle if some degree of sanity and balance is to be brought into an environment that is almost uniformly considered highly uneconomical in terms of physiological and psychosocial performance cost. The fervent hope for a miracle springs from the fact that much of the scientific and pseudo scientific research carried out in the ATS environment has failed to yield findings that unequivocally demonstrate significant differences between ATS controllers as a sample group and any selected non-ATS control group.

This must not be interpreted as necessarily suggesting that ATS is a non stressful environment, but it does mean that within the specific research program parameters, no significant differences could be demonstrated, and in the light of these non-findings, a realistic perspective must be kept when focussing on the need for

further research. Whether or not such future research programs do in fact occur, there are groups that are planning action that they expect (hope) will allow them to come to grips with the ATS stress problem.

Many of the discussions in current literature concerning the ATS problem are traditional in tone and refer to periods of exposure to intense job related stress and associated safety implications. Illness and absenteeism rates for controllers are cited and often the need for increased job satisfaction is stated as a potential cure-all. Despite this, there is compelling evidence suggesting that job satisfaction is in fact not a conern in ATS. An extensive study was conducted by the Aviation Psychology Laboratory of the Civil Institute of the Federal Aviation Administration to determine job satisfaction among a large number of controllers. Conclusions of the U.S. study, drawn from the information received indicated that on a scale of 0 to 100 percent controllers average a 91 percent level of job satisfaction. An abbreviated Canadian study, admittedly involving a much smaller sample consisting of tower controllers only, indicated a nearly equivalent 88 percent job satisfaction level. An additional important fact, emerging from both studies, is that controllers like, and in fact prefer, high levels of job activity. These findings raise some questions concerning the accepted belief that the stress of high work loads are necessarily detrimental to the self perceived well-being of the controller.

During a recent meeting hosted by the American Academy of Stress Disorder, a plan was taled on the suggestion of Dr. E. Eliot Benezra, a psychiatrist who has worked with a number of air traffic controllers. Dr. Benezra feels that a Crisis Intervention Team (CIT) should be available at all times to practicing controllers. The Team might consist in part of controllers with an aptitude and training to understand the emotional aspects of their colleagues.

In the light of scientific study findings and the crucial career impact of the stigma of psychiatric treatment there is some question about the validity and the wisdom of such a dramatic, and to the controller possibly traumatic, approach.

Another approach forseen by some as the solution of the human problem in the ATS man/machine system complex is the radical increase in instrument technology. It is suggested that an advance in the state of the art of raw information presentation systems will improve information processing ability by the human sub-system ans thus enhance aviation safety.

In terms of reducing ATS job stress this could prove to be a

questionable course as well. From what is known today, there are strong indications that the limits of man's mental capacity to absorb and process information are being reached, and that people capable of consistently handling present levels of complexity are becoming more and more rare.

In ATS, the introduction of more powerful and complex information presentation systems will require the controller to assimilate even larger quantities of data in a severely limited and critical time frame and it is possible that his or her physical and intellectual limits are being reached and will soon be traumatically exceeded. The other associated fact that ATS problem solvers must come to grips with is that a second complex man/machine system is involved in this already saturated system; that is the pilot/aircraft unit. It is suggested that a possible way of decreasing the mental loading on the controller would be to make cockpit instrumented aircraft proximity information available to the pilot as well as to the ATS controller during the critical final phases of flight. It is felt by some critics of the North American ATS Systems that this is not only desirable but mandatory in the interest of flying safety and reduction of human sub-system stress. The first step in future projects must be to clarify the questions and formulate legitimate empirical means to test the hypothesis. We need not re-make all of the mistakes.

Study Intent

Concern in this study lies with the traditional methods of laboratory research, the methods needed in the conduct of field research and the methodological issues and strategies appropriate for linking the domains of scientific activity in the field and in the laboratory, specifically in relation to predicting of physiological cost of human performance during continuous work under stressful conditions.

Although the questions asked by the researcher or user serve as the input to the research flow model, and are the driving force in all research, and provide the hypothesis to be tested in more formal scientific terms, they are never more critical and practical than when they provide information of a predictive or potential control nature for a consumer community. Initially the problems must be defined in such a way as to be meaningful to the user and researcher alike. Once this has been done, there may be information available by which the problem can be solved, either uniquely or through low cost tests of alternate solutions. Should a major research effort be required to generate the information needed, several strategies may be employed.

Any strategy or technique used, must meet specific researcher

and user criteria in that is must be:

a. Meaningful (to the consumer)

b. Standardized (results evaluated against defined standards)

c. Reproducible (results should be consistent when repeated)

d. Efficient (economic expenditure of investigation effort)

To offer research findings leading to applications for a meaningful solution to the user, the research design must be sufficiently flexible in its applicability to allow researchable universe substitution. In selecting Air Traffic Services (ATS) for scientific investigation, recognition was taken of the amazing stides made by civil aviation and how all forms of this transportation mode have affected the course of history by their strong influence on commercial, cultural and diplomatic relations. Efficiency, effectiveness and safety of air transport is in large measure due to the high professional qualities of the pilots and ground staff, such as Air Traffic Controllers. Among the ground services, ATS is the only one to have direct effect on the conduct of flight. The ATS man/machine enviroment systems complex has perhaps as its most valuable link the human being, for man is still the final and key element in the decision making.

In the event of an emergency, with the pilot having the responsibility for the aircraft in difficulty, only the air traffic controller can ensure that it has unobstructed air space and a cleared flight path. The air traffic controller must continue to control the movemnt of may aircraft simultaneously, often an many as 15, whether or not an emergency is in progress. Each decision msut be taken without delay and often without the possibility of recall.

Studies (1, 2, 3) indicate a high occurrence of cardiovascular and gastrointestinal disorder and suggest that top physical and mental condition are vital requirements for the air traffic controller. Staff are required to undergo stringent medical examinations identical with those given for professional pilots and these are repeated at relatively frequent intervals. A phrase often used by ATS staff to describe their work is "unavoidable high nervous tension", which it is felt can be compensated for by harmonious working environments, sutiable working hours and periods of rest (4).

It is suggested that is is important that an above average

to high standard of living should be provided for ATS personnel to relieve them of as many of the day to day worries as possible. This is seen as necessary because the air traffic controller's slightest error could cause considerable loss of human life and property. His professional occupation and living standard is at stake with each decision he makes.

What emerges strongly from all conversations and ATS seminars is the desire and felt need for special status. Since its founding in 1961, the International Federation of Air Traffic Controllers Association (IFATCA) has sought to protect and promote the profession of air traffic control. Through IFATCA access can be gained to the International Civil Aviation Organization (ICAO), the International Labour Organization (ILO) and many other specialized organizations such as the International Federation of Airline Pilots' Association (IFALPA). It is generally and genuinely felt by ATS that only recognition of the realities of the pressures of this occupation and rights of the profession will ensure that civil aviation can continue its development in the most complete security, safety and user confidence possible.

Within the framework of this research project and on the basis of the wealth of literature available on stress related behaviours and performance in ATS, it is suggested that the ATS proposals for handling the problems of stress may have inadequate scientific backing and as such are not yet adequately supportable.

1. A meaningful definition of stress has not yet been made, although Selye (5) offers compelling evidence of it being a non-specific biochemical response.

2. Biochemical stress indices historically used in research, although suggestive, do not in fact reflect the adverse nature of the stressor especially over long and/or repeated exposure.

3. Although special status and financial reward may make working under stress more profitable and financially acceptable, it will not alter the stressful nature of ATS employment which exacts its toll on the physical and mental being of the Air Traffic Controller.

4. The question of ATS physiological job cost has not been investigated in a manner adequately meaningful to the user.

What would be of significant benefit to ATS, is research directed towards finding the possible cause factors that have established ATS as a high risk form of employment (6, 7, 8, 9, 10)

and programs geared to experimental intervention aimed at either reducing the stress without comprising necessary work output and quality or at teaching the human being to cope better with the stress.

The comparison group in this project was selected from among federal government employees who are staff members of the Defence and Civil Institute of Environmental Medicine (DCIEM), a facility engaged in scientific research and operationally oriented application of findings. It is a fair assumption that performance demands are as high and failure penalties as personally critical as in the ATS environment, although the risk of psychiatric and clinical breakdown to the same degree as in ATS has not been demonstrated for DCIEM staff. On the contrary, the risk appears to follow the predictable general population pattern (11).

The descriptive model in this study cannot include all operational elements because of the complexity of interrelationships between the work environment, the task itself and the man performing the task. Study objectives are preliminary as are the analysis, the indentification of intially critical variables, and the testing of hypothesis dealing with the relationship between sub-strategies, in terms of physiological cost. The systems approach is thus incremental in concept and is a first attempt to formulate and operate within the step-wise flow model as indicated in Figure 1.

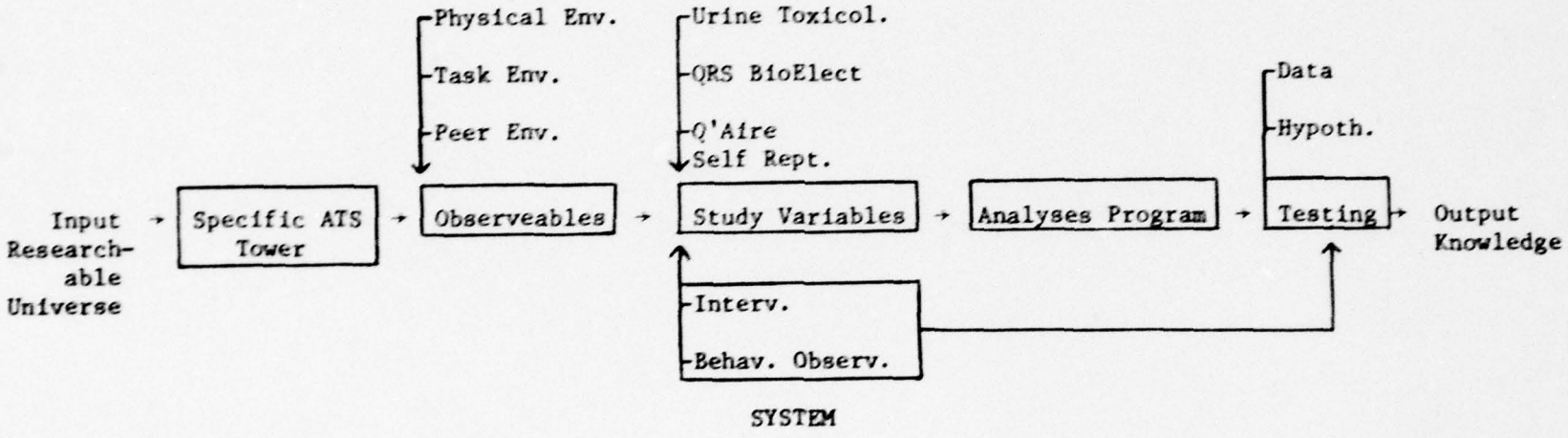
Research Method

The general objective of this basic research program is to develop and evaluate a brief series of research methods and strategies for future application to the determination of physiological cost of employment, which is both demanding and continuous in nature, while not impinging significantly on the ongoing workload of the subject group. Specific objectives are the determination of the internal and concurrent validity of measures and instruments used and the evaluation of research sub-strategies varying in style and content.

The occupational arena selected for this preliminary study was the airport control tower, which is a complex man/machine systems environment, considered stressful as a result of the substantial psychomotor performance demands made continuously on the human operator in the system. The sample of people chosen included both female and male controllers, capable of working in all tower positions, and with a precisely defined task. The ATS tower facilities selected were Toronto International (CYYZ) and Buttonville (CYKZ) airports. The controls consisted of female and male personnel employed at the Toronto based Defence and Civil Institute of Environ-

FIGURE 1

RESEARCH PARADIGM:
ATS/CONTROL CONTINUOUS OPERATIONS PHYSIOLOGICAL COST ASSESSMENT SCHEME



mental Medicine (DCIEM) an operationally oriented research and educational facility.

The control group in this study was selected on the basis of having a similar history to that of the sample. The significant difference being the assessment of control group employment as traditionally not stressful. This satisfies the system concept requirement that the output at any particular time, in any particular run is dependent only on sample condition and not on its future to that time.

All measurements and observations were carried out during a daytime working day, in the interest of sampling consistency.

All subjects were volunteers and because of the very small population to draw from, no limits on age, sex, marital status or length of employment were applied. With two exceptions the entire group fell between the ages 23 to 38 years of age, 80 percent were married, the group was predominantly male, and all but 5 of the group has been active in their present work between 1 to 10 years.

Data collection, reduction and analysis occureed over a seven month period and involved the following:

a. The development and assessment of a methodology for the screening of urine for toxicological substances present.

b. The application, data collection and analysis of a series of self reporting questionnaires allowing subjective psychophysiological state assessment.

c. The development and assessment of a methodology for continuous electrocardiogram monitoring for sinus arrhythmia analysis as a mental activity index.

Additional observations were made in an attempt to gain personal experience and knowledge which could prove to be of supportive value and these included the following:

1. in-depth interviewing following the duty period, and

2. continuous unobtrusive behaviour observations during duty.

In each of the methodological strategies, different measuring devices and instruments were used and to enhance the reader clarity of this study as well as to facilitate potential user orientation,

methods and instrumentation information is separated and is detailed appropriately.

The private interviews were carried out along structured lines, but were sufficiently flexible to allow the subject to digress in a guided manner. The intent was to obtain personal information allowing the author to make an informal subjective assessment of:

a. the working environment quality, and

b. psychosocial environmental needs.

TOXICOLOGICAL ANALYSIS

Chemical Countermeasures

The toxicological analysis in this study attempts to establish whether or not an individual participating may have subjected himself or herself to voluntary pharmacological countermeasures. In future studies it is envisioned that positive findings could be correlated to other sub-strategy results with the intent of presenting a specific objectively defined aspect of a reliable history of behaviour. Simple and reliable methods of analysis of biological specimens are not readily available to the non-medical scientists so the DCIEM toxicological chemistry laboratory was approached for this assistance.

Since invasive techniques were not planned for this study, all subjects were asked to submit three urine samples, each sample representing the first urine voided upon awakening on the morning of a duty day. Samples were required as follows:

a. the first sample to be submitted on the first day of duty during this study. If at all possible, this first day of duty should follow a period of rest between shift changes particularly where applicable to the ATS group.

b. the second sample to be submitted at approximately a mid-duty shift point.

c. a third sample to be submitted at any time within a two week period following collection of the first sample, as long as the sample was taken while on duty.

On submission, the urine was immediately frozen and transported

to the DCIEM laboratories where it was analyzed according to established methods.

Research literature reveals a perplexing array of screening methods. A requirement of this study was to produce reliable, meaningful data, but hopefully it was to produce a simple and relatively speedy procedure as well. Following consultations with DCIEM toxicology specialists it was decided to use this study to evaluate the feasibility of a multi sample modeling, satisfying the listed study research design parameters.

It was apparent that the types of methods planned were elegant and precise and not necessarily within the limits of routine experience, and the reader is reminded that this study is not concerned with industrial toxicology and no analytical efforts in that discipline are anticipated. Detailed descriptions on methodological techniques are not offered as it is considered within laboratory expertise and not part of this study. However a brief explanation of each technique is given.

For sensitivity drug screening, any isolated procedure is considered inadequate for identifying a compound, thus a combination of procedures, and subsequent procedure coupling is applied. It is considered that only in this way can sufficient information about a substance be provided, guaranteeing the reliability of a statement made about it. The test combinations are schematically presented in Figure 2.

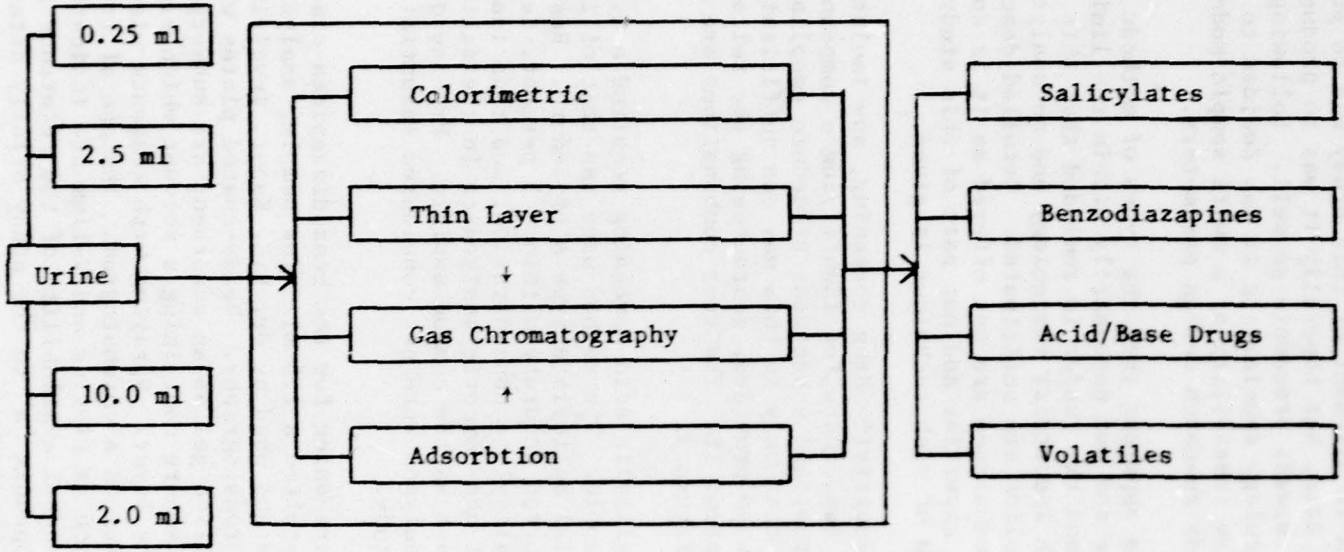
1. Salicylic acid screening required a 0.25 ml urine sample. The method used was that of Irving Sunshine, (12) Salicylate type A procedure. Results are reported accurate within ± 5 percent, determine urine salicylate concentration, and thus identify the use of non-narcotic analgesics in the salicylates group, such as the common aspirin. Precise quantitative analyses were not considered essential for this study.

2. Screeening for the benzodiazapines class of drugs required a 2.5 ml urine sample, analyzed by the method used by Dr. B.N. Kapur, involving thin-layer chromatography. Ready-coated plates with thin layer silica gel as an adsorbent are submerged in moisture chambers containing a solvent which migrates through the layer. Spraying with reagents visulaizes the drug on a chromatogram. The use of tranquilizers such as Librium and Valium are indicated. Pending general availability of the reference publication, Appendix "A" to the study briefly details in the Kapur method.

Urine screening in the study subjects was performed, by sample in the following manner:

FIGURE 2

THE TOXICOLOGY SYSTEMS MODEL



3. Sedatives and hypnotic classes of drugs required a 10.0 ml urine sample which was analyzed for the acid and basic drugs. The method used was that of John M. Meola and Michael Vanko, (13, 14) where drugs are absorbed from urine onto charcoal selectively eluted, and identified by thin layer chromatography. Positives are further investigated by gas liquid chromatography. The system used is the 7620A Research Chromatograph, 12 module complex, manufactured by Hewlett-Packard.

4. Determination of volatiles required a 2.0 ml urine sample, analyzed for presence such as ethanol, acetone, isopropanol, which indicates the use of alcohol or the presence of a potentially pathological condition, such as diabetes mellitus. The method used was that of Goldbaum et al (15). Positives are determined by the gas liquid chromatography method, using the Hewlett-Packard 7620A module complex Research Chromatograph, for identification of peaks.

Results Available and Judged Meanings

If a urine screening yielded a positive or positives, the urine sample subject was contacted by private means to ensure confidentiality and was then asked to voluntarily:

a. confirm the positive sample findings,

b. advise on voluntary use or clinically directed use of the substance identified,

c. state the reason for internal use of the substance identified,

d. state how the substance identified had been obtained,

e. state the frequency or situational use of substances identified.

If pathological significance was suggested from the urine sample, the subject was confidentially informed of the presence of the substance and its possible clinical significance.

Within the objectives and operational parameters and future applications of this study, positive urine screening results can be placed in a reciprocal relation to other sub-strategies findings and a judged meaning of significance can be made by the researcher.

Conclusion - Toxicological Analysis

At the risk of over simplification, it may be stated that the drugs identified by urine screening in this study are primarily classed as depressants, drugs that diminish the stae of alertness and decrease the impact the external environment has on the thoughts and feelings of the user. In spite of views strongly opposing drug use, the general acceptance of mood-modifying drugs by the general community is part of what many is considered to be normal living habits (16).

In this study recommendations relate only to adaptation of established urine screening methods to the research design tested and no data is presented although the results were available. The results were most encouraging from the technical standpoint and application to future multistrategy correlation research are strongly indicated, and urgently suggested. Urine screening can be effectively used in the future phases of this study as follows:

1. determination of toxicological subject baseline,

2. selection by screening of subjects for acceptance or rejection in a study,

3. comparative performance of a subject, untreated and cleaned,

4. subjects split on the basis of detected drug use, and

5. assessment of psychological and job behaviour through correlation between drug results and subjective questionnaire reporting.

BIOELECTRICAL ANALYSIS

Mental Activity Index

Heart rate variability, a research tool historically reserved for the medical sciences, affords methodological potential to the psychological and physiological sciences and to its application in the study of human performance as a field technique. Work reported (17, 18, 19, 20, 21) relates to its contribution to mental work and mental load. The obvious problem with this specific research strategy is its complexity of technology and the professional level of training required on the part of the researcher. Other problem areas lie in the standardization and interpretability of results as there are no absolutely clearly and conclusively defined standards against which judgement may be made (22).

Strategy Objectives

This study attempted an evaluation of standardization of recording methods and test conditions and aimed at determining the feasibility of drawing meaningful results from the data collected. While laboratory studies will be used in future studies for identification of critical biochemical variables related to load response in the operational environment, the heart rate field study hopefully will provide the linkage of theory with hypotheses and observations, and allow refinement of the research model.

This strategy rests upon the method of spectral analysis of sinus arrhythmia during mental loading. Heart rate irregularity will be used as a dependent variable during performance in an operational environment. The concept of sinus arrhythmia in this research strategy is not connected with pathology, i.e., irregularity increases under stress. A most interesting phenomenon is the suppression of the sinus arrhythmia (the irregularity of the heart rate pattern). There are indications that this occurs following changes in breathing pattern, a change in the vagal tone and that both kinds of suppression occur during mental load (23). It is now known that mental load will diminish irregularity without necessarily causing a rise in mean heart rate.

In future field studies, electrical heart activity as a dependent variable will be collected and analyzed. The most prominent electrical activity accompanying heart beat is the QRS complex in the ECG (the R-top). An approach to get the maximum amount of information out of an R-R time series will be formulated.

Methods

Data collection was accomplished through remote transmitting. The subject was fitted with 2 ECG chest leads which were connected to a small 2 lead electronic transmitter carried on the body. The signal range was approximately 30 feet. A standard FM radio was used to receive the ECG signal on a FM band frequency and used for signal strength and drift monitoring. Through an amplifier the ECG signal was transmitted to a storage oscilloscope which allowed further monitoring of quality. Accurate R-R counts in milli-seconds were transmitted to an instrument computer which is capable of storing the received pulse in appropriate, desired groupings. R-R counts were displayed on a second scope with the capability of recalling stored information for analysis. All ECG signals were recorded on tape for laboratory analysis.

Research Instruments

Since only standard commercial equipment items were used in

this study, no detailed operational description is offered, but instruments are identified.

For the recording and monitoring of continuous electrocardiograms during duty, the following equipment was taken to the field:

a. Skin cleaner for electrode application, a product of IVM, "In Vivo Metric" systems, P.O. Box 217, Redwood Valley, California 95470.

b. The electrodes for the two chest leads used, are a "Medi-Pad" disposable monitoring electrode, pre-gelled, manufactured by General Medical Corporation, Richmond, Virginia.

c. A small remote signal transmitter, pocket carried by the subject, transmitted on a discrete pre-selected FM frequency, manufactured by EKEG Electronics Co. Ltd., Vancouver, B.C.

d. A Sony, TFM - 7300 WA, AM-FM portable transistor radio to provide frequency monitoring by heart beat. The FM frequency range employed was 87.5 - 108 MHZ.

e. A portable, four channel, three speed instrumentation tape recorder using 1/4 inch magnetic tape and capable of FM recording. The 3960 series recorder, manufactured by Hewlett-Packard Company, 690E Middlefield Rd., Mountain View, California 94040.

f. Recording tape used, Scotch AV177 Tensor, low noise 1/4 inch magnetic for heavy duty applications by Minnesota Mining and Manufacturing Company, St. Paul, Minnesota 55101.

g. A display oscilloscope system consisting of display module and plug-in units. The power supply/amplifier module, the 5103M, the dual time base, a dual sweep plug-in. The system allows visual monitoring of ECG tracing quality and is manufactured by Tektronic Inc., P.O. Box 500, Beaverton, Oregon 97005.

Laboratory analysis of ECG data in this study required instrument items (e), (f), (g) in addition to:

h. A Tektronic Type RM 504 Oscilloscope, a low frequency, high sensitivity laboratory instrument providing accurate time and amplitude measurements.

i. A Fabri-Tek FT-1074 Signal Averager, an instrument computer providing memory, readout and arithmetic function in a main frame unit capable of accepting measurement control plug-in units. The unit can provide data to a data processor. The manufacturer is Fabri-Tec Instruments Inc., 5225 Verona Rd., Madison, Wisconsin 53711.

j. A PDP-9T a highly modified computer manufactured by Digital Equipment Corporation.

A copy of the analysis program used, appears as Appendix "B".

Results - Bioelectrical Analysis

Within the parameters set for this sub-strategy for bioelectrical measurements, study objectives were met, in that it was determined that continuous monitoring of electrical cardiac activity of subjects employed in high workload operations in the field is feasible. Subsequent laboratory analysis of data is within the capabilities of the equipment used in this study.

Major points emerging are:

1. In operational studies involving psychological measurement of stress using QRS complex analysis, it will be necessary to develop a method of precisely determining work activity during the monitored period so that the activity and the physiological response can be analyzed. This could be a simple paper-pencil, pre-determined time intervals, activity scale scoring to be done by the subject. This would allow more meaningful correlation of findings.

2. The feasibility of graphic voice analysis (sound spectogram) as a potential correlate will have to be investigated. Voice recording during EKG monitoring was accomplished on an experimental basis in this study. Play back revealed marked voice quality and sentence velocity changes that could prove significant as a stress indicator.

3. It appears difficult to observe and measure experimentally physiological cost of performance or performance decrement because of the complexity of the ATS multidimensional task. It raises the possibility that we are not measuring what we should be measuring. Ob-

servation strongly suggest that a task experienced individual can and does compensate for any presumed performance decrement on a particular aspect of the overall task.

4. It is possible that the self reporting questionnaires sub-strategy applied in this test is a more reliable, more economical, and a high integrity method of determining performance cost.

SELF REPORTING QUESTIONNAIRES

Adequacy of Sleep and Mood

Conservation of sustained performance is a critical factor in operational effectiveness. Many variables have a direct effect on the ability of man to efficiently function in an operationally oriented sense. Some of these variables are:

a. selection,

b. motivation,

c. training,

d. the psycho-, and physio-physical quality of the work environment,

e. design of task specific equipment,

f. the nature of the task, and

g. rest-work schedules.

Of these basic variables all of which are important in ultimately determining quality of performance related literature offers compelling evidence that quality and adequacy of sleep is possibly the single most fundamentally critical variable in the determination of the physiological cost of work (24). How much sleep man needs or how much sleep loss can be tolerated is extremely difficult to determine, and little is known about methods of economically and reliably measuring these parameters.

In this study subjective assessment strategies were used including self-report questionnaires obtained within the working environment rather than a laboratory setting. No attempt is made at performance decrement measurement due both to the sensitive nature

of the task performed by the Air Traffic Controllers and possible ramifications of feedback of such measures to either the subjects or to their employers.

Strategy Objectives

In the design of the research model of this sub-strategy the general priority objective was to obtain reliable and valid indicators, within the stated performance, of subjective assessments of sleep adequacy and quality as these might relate to future assessments of the physiological cost of performance. A second objective was to assess the validity, reliability and potential utility of existing questionnaires, while a third objective was the assessment of possible expenditures of time and money by the investigator to carry out a full scale study at a later date.

In the final analysis it is hoped that results will point the way to economical but effective future research strategies and that they will contribute to methodological advancement. As research instruments, three questionnaires were used:

1. Sleep Log and Stanford Sleepiness Scale, provided in Appendix "C".

2. Mood Scale, provided in Appendix "D".

3. Goldberg General Health Questionnaire, provided in Appendix "E".

All three questionnaires are relatively simple to administer "paper and pencil" tests, having in the view of their authors, at least a minimal demonstrated utility and reliability. Each questionnaire is individually detailed in this Chapter.

Sleep Log - Methods

The first measurement method employed is the Sleep Log, a simple self-reporting questionnaire in which the subject describes sleeping - waking behaviour on a 24 hour basis. The author and developers are Paul Naitoh, Ph.D. and Laverne Johnson, Ph.D., from the Naval Health Research Centre in California (25). Degree of sleepiness is assessed by the Standard Sleepiness Scale which appears on the reverse side of the questionnaire and was developed by Deurent et al (26).

In this research program subjects were requested to complete a questionnaire on the day following the duty day during which the field study occurred, and failing that, completion was requested following a duty day similar to the field study day in terms of

shift worked and day of the week. In this manner methodological consistency was maintained. Similar instructions were given to both the ATS sample, and the DCIEM control group.

Although statistical testing was applied to the CYYZ (N=14) and CYKZ (N=9) sample groups as independent samples, the small size of the CYKZ sample made validity of statistical testing suspect, and the CYYZ + CYKZ groups were combined into one (N=23) sample of a statistically adequate size for these preliminary efforts. The DCIEM control group was minimally acceptable with an N=16. The following groups were subjected to statistical testing in the Sleep Log category:

a. sample CYYZ, N=14

b. sample CYKZ, N=9

c. sample CYYZ/CYKZ, N=23

d. control DCIEM, N=16

e. NOK, N=23 (re-categorization is explained in the text)

f. OK, N=16 (re-categorization is explained in the text)

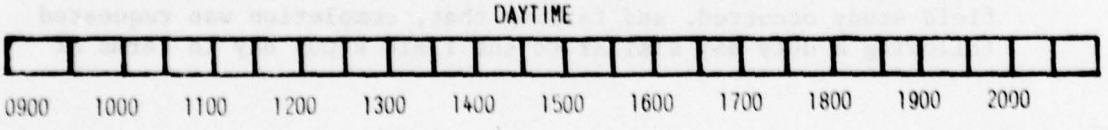
Sleep Log - Scoring Scheme

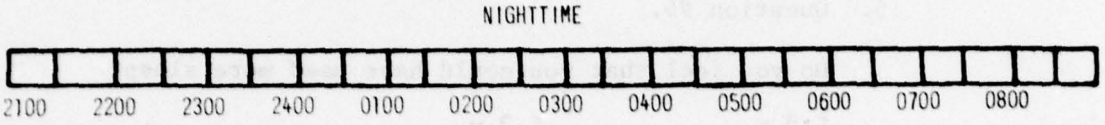
The author of this questionnaire, Dr. Paul Naitoh, was contacted regarding the use of the form and its scoring scheme. This investigator was authorized free use of the form and was advised to develop an independent scoring scheme. This was done and results were tabulated.

The scoring scheme determined for this study is applied to each question as follows:

1. Question #1.

   This question was not used in statistical testing. On the chart below draw a horizontal line through the squares corresponding to the half hour periods during which you were asleep during the last 24 hours. Put an X in the square corresponding to any half hour period during which you recall waking up for 15 to 30 minutes.





2. Question 2.

How much trouble did you have going to sleep last night?

[ ] None [ ] Slight [ ] Moderate [ ] Considerable Time to fall asleep

_____minutes

↑ ↑ ↑ ↑ ↑

0 1 2 3 Not scored

Scoring follows logically from the established idea that the most trouble free classification is represented by a zero score.

The "time to fall asleep" value was not statistically tested.

3. Question #3.

This question was not used in statistical testing.

How many times do you recall waking up last night?

_____ Not used.

4. Question #4.

How rested do you feel?

[ ] Well Rested [ ] Moderately Rested [ ] Slightly Rested [ ] Not At All

↑ ↑ ↑ ↑

0 1 2 3

Scoring is applied logically from 0 to 3, where zero is the trouble free classification, and the scoring is consistent with that of Question #2.

5. Question #5.

Do you feel that you could have used more sleep?

[ ] Yes [ ] No

↑ ↑

1 0

(NOK) (OK)

This extremely significant question is a binary choice item rating the perceived requirement for additional sleep. The "yes" or "no" answer allows additional and truly different categorization to the traditional "sample" and "control" group, and appears ideally suited to this and future studies. Recategorization of the researchable universe of this study is introduced, and on the basis of this question, the additional groups are, and will be identified in all results as:

a. The "Not OK" group; NOK.

A "Yes" answer is scored as one and is identified in this study as NOK.

b. The "OK" group; OK.

A "No" answer is scored as zero, the trouble free group, and is identified in this study as OK. This scoring is also consistent with the theme of scoring in Questions #2 and #4.

6. Question #6.

Today's Mood

[ ] Very Poor [ ] Poor [ ] Average [ ] Good Number of dreams recalled

_____

↑ ↑ ↑ ↑ ↑

3 2 1 0 Not used

To maintain score consistency the good mood classifications scores zero. Any score different from the zero score, serves as an indicator of increased performance

cost, "things are getting bad".

The "Number of Dreams Recalled" data was not used.

7. Question #7.

This question was not used in statistical testing.

Hours of work in last 24 hours?

_____ Not used.

8. Question #8.

Choose one of the seven statements below which best describes your present feelings. How you feel right now.

0 → (1) Feeling active and vital; alert, wide awake.

1 → (2) Functioning at a high level, but not at peak; able to concentrate.

2 → (3) Relaxed; awake, responsive, but not at full alertness.

3 → (4) A little foggy; let down; not at peak.

4 → (5) Foggy; slowed down; beginning to lose interest in remaining awake.

5 → (6) Sleepy; woozy; prefer to by lying down; fighting sleep.

6 → (7) Almost in reverie; sleep onset soon; losing struggle to remain awake.

The Sanford Sleepiness Scale which includes 7 subjective feeling classifications is scored from zero to six following the same scoring principle established in the preceeding questions. Statement (1) is awarded a zero score indicating a most trouble free feeling, followed by a logical sequential scoring indicating greater negative feelings and an increased performance cost.

Sleep Log - Analysis

In the first set of cases, in an attempt to establish the internal validity and reliability of independent scaling from one

question to the next, a series of correlations were performed on the following comparisons:

a. question #2 with question #4

b. question #2 with question #6

c. question #2 with question #8

d. question #4 with question #6

e. question #4 with question #8

f. question #6 with question #8

In the Sleep Log results sections, this analysis will be identified as "Case A".

The test protocol for the correlational analysis is as follows:

1. The formula used for the test of statistical significance is:

$$F_{1,N-2} = \frac{r^2}{1-r^2}(N-2) \quad (27)$$

where r is the correlation of the two items over the group or subgroup and is calculated by the formula

$$r = \frac{\Sigma XY - \Sigma X \Sigma Y/n}{\sqrt{[\Sigma X^2 - (\Sigma X)^2/n]\,[\Sigma Y^2 - (\Sigma Y)^2/n]}} \quad (28)$$

2. The level of significance is $\alpha = 0.5$

On the second set of cases, the Dunnett version of the t-test was performed on the differences between means of the sample (ATS, N=23) group and the control (DCIEM, N=16) group and between the OK Sleep Group (N=16) and the NOK Sleep Group (N=23) to test for the significance of observed differences in responses. The significance testing proceeds as follows:

1. ATS question #2 with DCIEM question #2

2. ATS question #4 with DCIEM question #4

3. ATS question #6 with DCIEM question #6

4. ATS question #8 with DCIEM question #8

5. OK Sleep Group with the NOK Sleep Group on Questions 2, 4, 6 and 8 respectively.

In the results, this analysis will be identified as "Case B". Test protocol is as follows:

1. The formula for Dunnett's Test is:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{o1^2}{N_1} + \frac{o2^2}{N_2}}}$$

(with $N_1 + N_2 - 2$ d.f., (29) using Dunnett's Tables to correct for the effect of multiple t tests)

Results - Case A

Correlations were performed with two different sets of criteria:

1. The air traffic tower controller subjects as the sample group compared with the DCIEM subjects as the control group.

2. The re-catergorization of the total study sample into an "OK" group and a "NOK" group on the basis of scoring of question #5 of the Sleep Log, as explained in the text.

Table T-1 shows the results of the correlations found for the combined CYYZ+CYKZ (N=23) sample. Table T-2 shows the results of the correlations found for the DCIEM group.

In Table T-1 of question #2 and #4 (a) yielded a non-significant correlation of r = .248. However, items (b), (c), (d) and (e) yielded correlations significant at the 5 percent level. The remaining correlation of question #6 with #8 (f) yielded a correlation of r = .363, which was non-significant.

TABLE T-1

COMBINED SAMPLE CORRELATION, CYYZ+CYKZ GROUP

	Items Compared	r	r^2	$1-r^2$	$F_{1, N-2}$	$F_{\alpha=@.05}$
a	2/4	.248	.060	.94	1.47	4.22
b	2/6	.483	.233	.77	6.30*	4.22
c	2/8	.608	.370	.63	12.39*	4.22
d	4/6	.426	.181	.82	4.62*	4.22
e	4/8	.582	.340	.66	10.92*	4.22
f	6/8	.363	.130	.87	3.15	4.22

* = significant at $\alpha = .05$

TABLE T-2

CONTROL GROUP CORRELATION DCIEM GROUP

	Items Compared	r	r^2	$1-r^2$	$F_{1, N-2}$	$F_{\alpha=@.05}$
a	2/4	.323	.1	.9	1.56	4.60
b	2/6	.269	.07	.93	1.05	4.60
c	2/8	.288	.08	.92	1.22	4.60
d	4/6	.542	.29	.71	5.72*	4.60
e	4/8	.827	.68	.32	29.75*	4.60
f	6/8	.338	.11	.89	1.73	4.60

* = significant at $\alpha = .05$

Significant correlations of r = .542 and r = .827 were yielded on the comparison of questions #4 and #6, and #4 and #8 respectively. This is consistent with the findings on these two correlations in the CYYZ+CYKZ group.

Tables T-3, and T-4 show the results of the correlational analysis performed on the re-categorized "OK", (N=16), and the "NOK" (N=23) samples.

TABLE T-3

Re-CATEGORIZED SAMPLE CORRELATION, OK SLEEP GROUP

	Items Compared	r	r^2	$1-r^2$	$F_{1, N-2}$	$F_{@\alpha=.05}$
a	2/4	.152	.02	.98	.28	4.60
b	2/6	.292	.09	.91	1.4	4.60
c	2/8	.114	.01	.98	.14	4.60
d	4/6	.590	.35	.65	7.56*	4.60
e	4/8	.529	.25	.75	5.18*	4.60
f	6/8	.236	.06	.94	.84	4.60

* = significant at $\alpha = .05$

Only items (d) and (e) where in (d) question #4 was compared with question #6, and in (e) where question #4 was compared with question #8 were correlations yielded at significant levels of r = .590 and r = .529 respectively.

Only item (e) where question #4 and #8 were compared, did correlation occur at a significant level (r = .524). In all other conditions correlation coefficients were not significant.

TABLE T-4

RE-CATEGORIZED SAMPLE CORRELATION, NOK

	Items Compared	r	r^2	$1-r^2$	$F_{1, N-2}$	$F_{=@}$ .05
a	2/4	.042	0	1.0	0	4.32
b	2/6	.361	.13	.87	3.15	4.32
c	2/8	.389	.15	.85	3.78	4.32
d	4/6	.059	0	1.0	0	4.32
e	4/8	.524	.27	.73	7.77*	4.32
f	6/8	.012	0	1.0	0	4.32

* = significant at α = .05

RESULTS - CASE B

Table T-5 shows the results of Dunnett's Tests performed on the differences between the means of the scores on Sleep Log questions #2, #4, #6 and #8, for the CYYZ+CYKZ (N-23) and DCIEM (N = 16) groups.

Table T-6 shows the results of the t-tests performed on the differences between the means of the scores for the OK (N = 16) and NOK (N = 23) groups.

TABLE T-5

SAMPLE AND CONTROL T-TEST

CYYZ+CYKZ Group		N = 23	t calculated	Comparisons tested	t required for significant result	DCIEM Group		N = 16
#2	$\bar{X}$	.478	t = 1.02	#2/#2	t = 2.021	.625	$\bar{X}$	#2
	σ	.846				.957	σ	
#4	$\bar{X}$	.783	t = 0.14	#4/#4	t = 2.021	.813	$\bar{X}$	#4
	σ	.518				.834	σ	
#6	$\bar{X}$	.783	t = 1.42	#6/#6	t = 2.021	.5	$\bar{X}$	#6
	σ	.600				.516	σ	
#8	$\bar{X}$	1.435	t = .53	#8/#8	t = 2.021	1.625	$\bar{X}$	#8
	σ	1.080				1.147	σ	

Note: all t calculated are non-significant

TABLE T-6

OK AND NOK T-TEST

OK Group		N = 16	t calculated	Comparisons tested	t required for significant result	NOK Group		N = 23
#2	$\bar{X}$	.125	t = 2.86*	#2/#2	t = 2.021	.826	$\bar{X}$	#2
	σ	.342				1.03	σ	
#4	$\bar{X}$	.313	t = 5.79*	#4/#4	t = 2.021	1.130	$\bar{X}$	#4
	σ	.479				.548	σ	
#6	$\bar{X}$	.375	t = 2.86*	#6/#6	t = 2.021	.869	$\bar{X}$	#6
	σ	.5				.548	σ	
#8	$\bar{X}$	.750	t = 4.3*	#8/#8	t = 2.021	2.04	$\bar{X}$	#8
	σ	.846				.928	σ	

* Significant at $\alpha = .05$

In contrast to the T-5 results, in the OK and NOK analysis of variance tests, results on all questions, t-value obtained exceeded the critical value of t=2.021.

Conclusions - Sleep Log

An overview of the statistical findings that flow from the analysis of the Sleep Log data demonstrate two facts that are important, both in terms of the present study, and for future applications of this assessment instrument. First, there is strong consistency shown in the relationship between several items of the Sleep Log. While the results do not show an absolute relationship, the demonstrated significant correlations show that an assessment of how well rested a person feels himself to be (question #4) is highly predictive of how positively he describes his present feelings (question #8). Similarly but with less certainty, one may infer that a paralled assessment of how well rested the individual feels (question #4) will be predictive of how good, or bad he assessed his mood to be (question #6).

These results are far from surprising or novel, but they are a preliminary objective demonstration of the folklore fact that how well rested one is, determines to a great extent how good a person's mood is and how well prepared he is to perform his duties or work. The internal consistency established in this study argues for the further use of this paper and pencil test in future studies to examine the effect, on both individual responses and cluster of responses, of stressful environments and/or of the use of mood altering drugs and other tactics employed to counter stress.

Secondly, the absolute consistency of significant differences between the mean scores obtained on the Sleep Log items by the sleep OK and NOK groups, show that the four individual items tested (questions #2, #4, #6 and #8) are able to discriminate well between respondents reporting differently on the binary choice OK, NOK criterion. Again, this result indicates that the future use of this sub-categorization of groups on the binary choice basis will be a most profitable tool for the description and assessment of experimental and comparative groups as researchers attempt to establish the sources of stress and the responses of the individual both within and outside of his work cycle.

Taken together, the internal consistency and group to group significant differences strongly aruge for the utility and applicability of this instrument to further studies of abnormal and stressful environments.

Mood Scale - Methods

The Mood Scale allows the individual to describe subjectively his feelings of alertness, emotional state, social disposition and general mood. The scale is reputed to be a sensitive indicator of potential causes of performance decrement. The questionnaire was developed by the authors of the Sleep Log scales described earlier in this paper (30).

In the interest of consistency, the subjects participating were requested to complete the questionnaires, following the same instructions as those applied to the completion of the Sleep Log.

The groups tested were defined on the established criteria for this study as follows:

a. CYYZ + CYKZ (N=23) versus DCIEM (N=16)

b. OK (N=16) versus K (N=23)

Mood Scale - Scoring Scheme

Scoring insturctions, as these appeared in the literature, were followed and each of the four possible response categories were assigned a weight as follows:

NOT AT ALL	A LITTLE	QUITE A BIT	EXTREMELY
0	1	2	3

The scale contains 19 positive items representing the positive (P) score. These positive items reflect feelings and behaviour that generally decrease with inadequate or restless sleep. As a function of the weighting of the response catergories, the P score can range from 0 (0x19=0), extremely sleepy, to 57 (3x19=57) extremely active and alert.

The scale contains a further 10 negative items representing the negative (N) score. Negative scores usually increase following sleep inadequacy and can range from 0 (0x10=0), extremely active and alert, to 30 (3x10=30), extremely sleepy.

The positive and negative items are identified on the Mood Scale questionnaire as follows:

In addition to the N and P Mood Scale scoring schemes, for the purposes of analysis, a combined score labeled Composite (C), consisting of the (P) score minus the (N) score (P-N=C) has been calculated for each subject.

The derived indicators for analysis of the Mood Scale in this study are:

a. Sum of negative scores (N = 30 Max)

b. Sum of positive scores (P = 57 Max)

c. Sum of composite scores (C = P - N)

Scores	N	P	C

A fourth parameter has been applied to the Mood Scale, as earlier stated in the methods section, which uses the binary choice sub categorization item on the Sleep Log Scale. The significant feature of this categorization and scoring is sleep adequacy, which was defined as follows:

Do you feel that you could have used more sleep?

[ ] YES	[ ] NO
NOK	OK
↑	↑
1	0

Mood Scale Analysis

On the basis of the three scoring indices N, P and C, a series of Dunnett's tests were performed to determine if a significant difference existed between the means of the various groups. On the basis of the criteria established for the study, these groups are:

1. (CYYZ + CYKZ) versus DCIEM

2. OK versus NOK

The (CYYZ + CYKZ) represents the ATS tower sample group at N=23, while the DCIEM represents the control group at N=16. The second category identified the adequate sleep group, OK at N=16 and the non-adequate sleep group, NOK at N=23. It is noted that the similarity of the sample size in both groupings of the subjects is purely coincidential and does not suggest that NOK with N=23 is in fact the CYYZ/CYKZ sample at N=23. The basis for recategorization was sleep adequacy and not place of employment.

The testing protocol is as follows:

a. The assumption of a null hypothesis is that the (CYYZ + CYKZ) sample group represents an occupation not significantly different from the DCIEM control group in their responses to this questionnaire. The alternate hypothesis (H_1), states that a significant difference does exist between the groups tested.

NAME						AGE	SEX	DATE	
ITEM	NOT AT ALL	A LITTLE	QUITE A BIT	EXTREMELY	ITEM	NOT AT ALL	A LITTLE	QUITE A BIT	EXTREMELY
ACTIVE					GOOD-NATURED				
ALERT					GROUCHY				
ANNOYED					HAPPY				
CAREFREE					JITTERY				
CHEERFUL					KIND				
ABLE TO CONCENTRATE					LIVELY				
CONSIDERATE					PLEASANT				
DEFIANT					RELAXED				
DEPENDABLE					SATISFIED				
DROWSY					SLEEPY				
DULL					SLUGGISH				
EFFICIENT					TENSE				
FRIENDLY					ABLE TO THINK CLEARLY				
FULL OF PEP					TIRED				
SCORES:	N	P	C		ABLE TO WORK HARD				

b. Similarly the null hypothesis for the OK, NOK groups comparison assumes that these groups do not differ significantly on their responses while the alternate hypothesis states that the groups do indeed differ significantly.

c. The level of statistical significance is = .05.

d. Dunnett's test uses the formula:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sigma 1^2}{N_1} + \frac{\sigma 2^2}{N_2}}} \qquad \text{(with } N_1 + N_2 - 2 \text{ dif.)}$$

Results - Mood Scale

Tables T-7 and T-8 show the results of Mood Scale Scores by the subjects as sample and control groups and as re-categorized on the basis of sleep adequacy.

Conclusions - Mood Scale

The results indicate that there are strong and significant differences in the Mood Scale, as a function of whether a subject sees himself or herself as having experienced a good night's sleep. It is only when this sorting is applied, on the basis of subjective assessment of sleep adequacy that consistent differences are found across all three categories of scoring; N, P and C; indicating the potential utility of the Mood Scale as a sensitive and valid indicator of perceived subjective differences in mood following sleep. Again, indications are that the popularly held belief that sleep adequacy affects mood in a direct relationship, i.e., better mood relates to adequate sleep and poorer mood relates to inadequate sleep. In this case P scores were significantly higher for sleep OK than for sleep NOK and N scores were similarly lower.

For future use, this scale offers an opportunity to measure the individual's personal assessment of his mood and since it has been demonstrated here that this scale shows significant differences on the basic sleep OK, NOK categories, it would be expected that similarly finely tuned significant differences should be found for those using mood altering drugs or other tactics to cope with stressful environments.

Goldberg (GHQ) - Methods

The 30 item, Goldberg General Health Questionnaire (GHQ) used in this study is a derivative of the long form, 190 questionnaire developed by Dr. David P. Goldberg (31). The 30 item questionnaire

TABLE T-7

DUNNETT'S TEST FOR DIFFERENCE OF MEANS

(CYYZ + CYKZ) GROUP VS DCIEM GROUP

CYYZ+CYKZ Group		N = 23	t calculated	Comparisons tested	t required for significant result	DCIEM Group		N = 16
C	$\bar{X}$	26.13	t = .76	C/C	t = 2.021	28.81	$\bar{X}$	C
	σ	11.19				10.65	σ	
N	$\bar{X}$	4.74	t = 1.02	N/N	t = 2.021	3.5	$\bar{X}$	N
	σ	3.93				3.6	σ	
P	$\bar{X}$	30.74	t = 2.72*	P/P	t = 2.021	23.31	$\bar{X}$	P
	σ	8.60				8.26	σ	

* The results show that only in the positive category was there a difference between the scores at a significant value for the test at t = 2.72 (exceeding the critical value of t = 2.021).

TABLE T-8

DUNNETT'S TEST FOR DIFFERENCE OF MEANS

SLEEP OK GROUP VS SLEEP NOK GROUP

OK Group		N = 16	t calculated	Comparisons tested	t required for significant result	NOK Group		N = 23
C	$\bar{X}$	34.75	t = 4.06*	C/C	t = 2.29	.22	$\bar{X}$	C
	σ	11.00				7.29	σ	
N	$\bar{X}$	2.00	t = 3.5*	N/N	t = 2.29	5.78	$\bar{X}$	N
	σ	3.26				3.39	σ	
P	$\bar{X}$	36.75	t = 3.7*	P/P	t = 2.29	27.65	$\bar{X}$	P
	σ	8.39				6.17	σ	

* Significant at α : .05 level

When the groups were pooled and recategorized into sleep adequacy (OK) and non sleep adequacy (NOK) groups, table T-8 shows the results. Significant t values exceeding critical t values in all these indices were found.

was made available by the Clarke Institute of Psychiatry for this study. No attempt was made to modify the general categories represented by the 30 items.

Presented in Table T-9 is the questionnaire's layout.

The scoring method as suggested in the literature by Goldberg which he says offers diagnostic value and simplicity, is for example as follows:

Question #27 - been feeling reasonably happy, all things considered?

	more so than usual	about same as usual	less so than usual	much less than usual
	↑	↑	↑	↑
Score	0	0	1	1

This four-way scoring pattern forces the elimination of a central response tendency by assuring a left or right bimodal response choice.

It was felt that this scoring scheme could result in the loss of potentially valuable information, and in an attempt to clarify and perhaps improve the utility of the Goldberg scale, the content was examined logically and the decision was made to use a different, less mathematically discontinuous scoring scheme, as well as the dichotomous orginator's preferred scheme. To this end, the following scoring was also applied:

Question #26 - been feeling hopeful about your own future?

	more so than usual	about same as usual	less so than usual	much less hopeful
	↑	↑	↑	↑
Score	-1	0	1	2

This scoring scheme is consistent with the approach established in this study, showing a numercial lowering of the score as subjective improvement occurs, suggesting better performance at decreased physiological cost. The first category listed is to be scored as -1 indicating improvement or movement away from the zero score, which itself identified a "no change", "same as usual" situation. A score of 1 is indicating a worsening situation, while a score of

TABLE T-9

THE 30 ITEM GHQ

CATEGORY	NUMBER OF ITEMS	LOCATION ON 30 ITEM GHQ
A General Health and Central Nervous System	1	Question #1
B Sleep and Wakefulness	4	Questions #2 → #5
D Observable - Personal Behaviour	4	Questions #6 → #9
E Observable - Relations with Others	2	Questions #10 → #11
F Subjective Feelings - Inadequacy, Tension Temper	10	Questions #12 → #21
G Subjective Feelings - Mainly Depression and Anxiety	9	Questions #22 → #30

In the interest of consistency, subjects were requested to complete this questionnaire following the same instructions as had been applied to all the other questionnaires used. The groups were derived on the basis of criteria established for this study as follows:

1. (CYYZ + CYKZ), (N=23) versus DCIEM (N=16)

2. OK (N=16) versus NOK (N=23)

GHQ (30) - SCORING SCHEME

2 has a judgemental meaning of considerable negative potential.

The additional sample scoring parameter applied to the GHQ in this study is the binary choice item found in the structure of question #5 of the Sleep Log Scale.

GHQ (30) - Analysis

For each of the scoring schemes applied (a) 0/0/1/1, and (b) -1/0/1/2, Dunnett's tests were performed to determine if a significant difference could be demonstrated between the mean scores obtained. The groups once again are:

a. (CYYZ + CYKZ), (N=23) versus DCIEM, (N=16)

b. OK, (N=16) versus NOK, (N=23)

In the first group, the (CYYZ + CYKZ) groups represents the total ATS tower sample and the DCIEM group is the control. The second group is a result of sorting of the entire population of this study (N=39) on the basis of the subjectively determined sleep adequacy thus creating the two groups identified.

The test protocol is established as follows:

1. The assumption is made that employment of the ATS group of subjects is not significantly more stressful than that of the essentially office and research oriented DCIEM control group. This is the null hypothesis (Ho). The research hypothesis (H_1) assumes a difference in either a positive or negative sense.

2. The statistical level of significance is $\alpha = .05$

3. The Dunnett's test formula used is:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sigma 1^2}{N_1} + \frac{\sigma 2^2}{N_2}}} \quad \text{(with } N_1 + N_2 - 2 \text{ df.)}$$

Results - Sample vs Control

The results under the 0/0/1/1 scoring scheme are shown in table T-10, while Table T-11 shows the analysis on the OK and NOK sleep adequacy re-categorization.

TABLE T-10

DUNNETT'S TEST OF DIFFERENCES OF MEANS ON THE GHQ USING THE 0/0/1/1 SCORING SCHEME (SCORE A) FOR THE ATS VS DCIEM GROUPS

CYYZ+CYKZ		N = 23	t calculated	Comparisons tested	t required for significant results	DCIEM		N = 16
Score Scheme 0/0/1/1	$\bar{X}$	2.78	t = .49	Score (a)	t = 2.021	2.19	$\bar{X}$	Score Scheme 0/0/1/1
	σ	4.44		Score (a)		3.15	σ	

TABLE T-11

DUNNETT'S TEST OF DIFFERENCES OF MEANS WITH THE 0/0/1/1 (SCORE B) SCORING SCHEME FOR THE OK VS NOK GROUPS

OK		N = 16	t calculated	Comparisons tested	t required for significant results	NOK		N = 23
Score 0/0/1/1	$\bar{X}$	.875	t = 2.69*	Score (b)	t = 2.021	3.695	$\bar{X}$	Score 0/0/1/1
	σ	1.707		Score (b)		4.606	σ	

* The results indicate a significant difference only in the re-categorized sample analysis.

TABLE T-12

DUNNETT'S TEST OF DIFFERENCE OF MEANS ON THE GHQ

USING THE 1/0/1/2 SCORING SCHEME FOR THE ATS VS DCIEM GROUPS

CYYZ+CYKZ		N = 23	t calculated	Comparisons tested	t required for significant result	DCIEM		N = 16
Score -1/0/1/2	$\bar{X}$	-9	t = .81	Score (a)	t = 2.021	-11.25	$\bar{X}$	Score -1/0/1/2
	σ	10.18		Score (a)		7.11	σ	

TABLE T-13

DUNNETT'S TEST OF DIFFERENCES OF MEANS

WITH THE -1/0/1/2 SCORING SCHEME, SLEEP ADEQUACY GROUPS

OK		N = 16	t calculated	Comparisons tested	t required for significant results	NOK		N = 23
Score -1/0/1/2	$\bar{X}$	-13.93	t = 2.4*	Score (b)	t = 2.021	-7.13	$\bar{X}$	Score -1/0/1/2
	σ	6.92		Score (b)		9.38	σ	

* As with the Goldberg scoring scheme, the modified scoring scheme added in this study, yielded a significant difference only when applied to the re-categorized groups on the basis of sleep adequacy.

Conclusions - General Health Questionnaire

In parallel with the results obtained from the other paper and pencil tests, the GHQ results show that responses on this instrument do discriminate well between those reporting adequate sleep versus those reporting non-adequate sleep. This questionnaire extends the time frame of the self assessment back beyond the present or recent past in that it asks for the self evaluation over the past month.

In future studies it will be most useful in allowing the researcher to extend the time scale of his assessment of change and how it affects perceived general health, beyond the day by day assessments possible with the Sleep Log and Mood Scale.

Conclusions - Combined Findings

What has emerged is that all of the applied scales are useful in that they allow a significant differentiation between people who consider themselves to be (a) sleep deprived or (b) not sleep deprived, in the sense only of adequacy of sleep as it was subjectively assessed. On that basis there is an internal consistency and validity to the Sleep Log in that solid correlations were demonstrated between how well rested the subject felt (question #4 Sleep Log) and how well he felt in terms of being ready and able to work (question #8) and to a slightly lesser entent with his present mood (question #6).

It is of interest that only one subject in the combined ATS group and again only one in the DCIEM group scored 4 (a somewhat negative response) in question #8 in the Sleep Log. All other subjects felt themselves to be in a relatively responsive and alert performance state. Essentially all scores in the Stanford Sleepness Scale (question #8 Sleep Log) were in the 0, 1 and 2 range.

There is strong internal consistency in that, if the only information obtained concerned the adequacy of sleep (question #5 Sleep Log), reasonable predictions could be made about how well rested one would feel the next day and what the perceived mood would be. This means that some prediction about potential quality of performance can be made.

The judgement must be that the combined Sleep Log and Stanford Sleepiness Scale is useful. It offers excellent internal consistency and does identify items about individuals that should be known before measuring other variables. All items contained in the Sleep Log are seen to be valid subjective indicators because they do relate to each other logically and significantly.

The Mood Scale offers much useful information on the basis of

the re-categorization of subjects into the subjective sleep adequacy NOK and OK groups. The questionnaire shows that significant differences exist between groups that have rated themselves as sleep adequate (OK) or sleep inadequate (NOK) on all three of the derived indicator scores (N, P and C) that emerge from the mood scale.

Findings on the basis of the division of the subjects into an (ATS) sample and (DCIEM) control group, indicate the only area where there is a significant difference is in the positive (P) index. This study strongly implies that the Mood Scale offers good internal consistency and reliability when applied on the basis of subjectives assessment of sleep adequacy, and thus is a useful tool in finer mood definition on a here and now basis in all of the three mood indices (N, P and C).

With the Goldberg questionnaire, in both the standard (0/0/1/1) binary scoring and the suggested modified (-1/0/1/2) scheme there appears to be no significant differences between the (ATS) sample group and the (DCIEM) control group. When the subjects are again re-categorized into OK and NOK groups on the basis of sleep adequacy, significant differences are demonstrated between their ratings. Thus a degree of interrelation between sleep adequacy, performance, mood and general health as subjectively determined is clearly apparent.

The conclusion must be that with the kind of agreement between the questionnaire used, the investigator should feel satisfied and encouraged in approaching larger groups on the basis of sleep adequacy categorization as well as job categorization. The possibility exists for continuing research on the further sub-categorization on the basis of medication received to off set negative mood states and their effect on measured performance.

PERSONAL INTERVIEWS

Why Do People Select Air Traffic Services

Very few of the controllers interviewed had selected the ATS field of employment as a first specific choice. Aviation interests were a guiding factor for most and for those who had obtained actual experience in the piloting of aircraft, ATS was invariably a second option occupation. For the majority interviewed for whom a flying career was potentially available, the profession of airline pilot was discarded either because of fear of early medical loss of license, with the associated loss of earning power and security, or because the competition to reach the top as an airline pilot appeared too formidable an obstacle. This suggests that ATS employment was selected for reasons of achievement ease and long

term security and because it was associated with aviation. For those who had never tried their hand at flying, it still held sufficient attraction to make many wish that they had at least given the flying of aircraft a try.

Employment Satisfaction

Job satisfaction is of a high order in the group interviewed and during the personal interviews it became apparent that the level of satisfaction could well be substantially higher than the 88 percent indicated by the personal questionnaires. Typical comments echoed by many reflected this in statements such as:

"I like it 100 percent and would like to climb in the ATS hierarchy".

"Am really very happy. It's not a job, it's a pleasure".

"I look forward to coming to work".

"Would like to remain in the system".

Tower controllers come across as confident, strongly authority oriented, and critical of any influence negatively affecting their perceived high job status. In their subjective assessment of personal job quality they rigorously evaluate their own performance, and often compare their profession with that of the pilot, who represents the external human sub-system in the broad ATS man/machine systems complex.

Although there is the possibility that some of the comments expressed are influenced by the controllers suppressed desires to be pilots themselves, the comments do offer what must be considered strong evidence of the very positive view that tower controllers have of their professional performance. For example some said:

"You may be wrong, but you are never in doubt".

"Pilots have no more capability than we do: ATS is more demanding".

"I have not seen too many pilots who have the complete picture".

"As a pilot you control one aircraft - I control many".

"Some pilots have failed as controllers, controllers have never failed as pilots".

"I don't think pilots are superior. It does balance out, we are even".

"Being a pilot may be more glamorous, being an air traffic controller is more demanding".

"We are elite. We are the top of the heap".

There is little doubt that the work itself, that of controlling air traffic, met with an almost unanimously high degree of approval. It was particularly interesting that the tower controllers, without exception, rated moderate to high work load as favourable. They clearly preferred its challenge and responsibility and would regard with dislike low traffic density condition. When asked to subjectively assess their stress tolerance, the ratio of "high" and "above average" to "average" was 2:1. No one interviewed perceived his or her job stress tolerance to be less than average.

This does not suggest that the tower controllers were without criticism of either the system or their peers and profound dissatisfaction was expressed concerning policy, administration and working conditions. One feature of the dislike of management was that the further away either geographically or professionally, the more serious the criticism became, that is, local supervision was accepted, regional supervision was suspect and Ottawa based supervision was regarded with profound concern. It was generally felt that in the decision making process, very little participation was allowed or requested from the operational level, the actual "sharp end" of the ATS system. There was a high degree of agreement that any visible controller participation in management carried little weight and this resulted in feelings of abandonment, aloneness and deep frustration. The "management/labour" relations which claim to be attempting to help the controllers were very much considered a major area for producing high stress.

The Working Environment

In this study no attempt was made to evaluate the technological status and job related efficiency of the electronic equipment used in controlling of air traffic. However opinions were solicited and observations were made that reflect on the professional and personal habitability of the physical tower cab, even if we assume equipment suitability. Generally, controller satisfaction and acceptance was low. Comments that reflected the dislike were for example:

"The place is very depressing, so I dress brightly".

"When overcast, the place is deadly".

"I do not like its remoteness. It should be where the people are".

"Glare is disturbing".

"Climatic control and layout are poor".

"No restroom facilities and dirty locker rooms".

It is quite surprising that tower cab design has incorporated so little of available information and knowledge about design of work space. This investigator feels that one of the reasons that more strongly voiced objections to tower cab design have not been raised is that tower controllers who must look out, can look out and have a wide, often fascinating and colourful panoranma, filled with motion and variety and they attend to that rather than the unpleasantness in which they are ensconced. It is a visula panorama that represents the focus of their responsibility. As a working space it remains unsatisfactory and by the concern it causes and the adverse effect it has on functional effectiveness, it must be assessed as a contributory stress factor, increasing physiological performance cost. Habitability was clearly compromised by each of thenegative factors raised by the tower controllers.

Social Needs and Ego

Man's need to belong to a group, no matter how vaguely defined or ethereal, is well satisfied by being an air traffic controller. The group under observation had, by its own assessment and design, established itself well as a strongly elite entity. Attempting to fit in has consequences not always to the advantage of the incoming controller. Because some had been unable to comply in specific areas of perceived elite demands, the formation of small sub-groups had resulted. These were ill defined but capable of accomodating specific individuals.

Self image is strong and positive and is reflected in the mode of dress and general grooming which, in the facilities observed in this study, was at a very high level. It is clear that punctuality and performaance, in addition to immaculate appearance, are strong ego feeding factors and are of paramount importance to the controllers. They add, in considerable measure, to improved self-image and confidence. All this translates into making ATS controllers

well motivated achievers.

Management would do well to recognize this and realize that proper usage of ego boosting ploys and paying attention to the areas of personal dignity and pride could well be the most powerful tool in management armamentarium. The tower controllers who were observed think of themselves as the best in the world. Quite possibly they are.

Place of Residence and Recreation

In the selection of the location of a place of residence the air traffic controllers were pratical and made a decision on the basis of (a) type of dwelling, (b) social class of others living in the area and (c) proximity of resources such as shopping centres, transportation and educational facilities in that order of priority. The majority felt that a significant feature of their dwelling should be that it have an area such as a den that would provide privacy and a place to "unwind". Decoration would be subdued in subtly blending warm, dark tones. The uniformily expressed need for this privacy suggested the major importance for this requirement.

Their recreational needs were predominantly non-team, non-violence oriented and reflected the preference for outdoor open space activities and quiet indoor hobbies with a high degree of creativity and personal satisfaction. Not surprisingly in view of the stingent medical standards for the profession, the majority of the controllers related strongly to the need for physical fitness. In these needs and hopes they did not differ significantly from the control group.

Conclusions - Interviews

The objective is to make an informal appraisal of how ATS tower controllers respond to their environment, what their subjective assessment of ATS is and how these factors might relate to physiological performance cost. Unfortunately, as in any other area of mythology, a body of non-scientific attitudes, opinions and ideas have evolved around the role and being of the air traffic controller, giving ATS an often mystical and mythical status. While some of the myths contain elements of truth and reality, occasionally even including factual accounts of their origins there is an overwhelming feeling that one is dealing not with scientific studies but with a collection of myths.

With the concurrence of those being studied, an attempt has been made in this appraisal to let the tower controllers give their side of the story as well as formulating analysis on the basis of unobtrusive observation of activities over a specified period of time. A better understanding of who controllers are and what their approach to life and work is, is essential to the direction future research must take. So to this end, this sub-strategy allowed the controller to "free-associate" during the personal interview, so that a better insight into the ATS human could be obtained.

What emerged is that one must conclude that we are dealing with highly motivated professional individuals who have felt and manifestly responded to the need to become something that is worthwhile. They are involved in a type of employment that forces them to mature rapidly and one in which a high degree of satisfaction is experienced, probably more so than is the case with most people who work. It appears that air traffic controllers have much in common with people in other occupations and do not appear to differ significantly when specific comparisons are made.

But because of the nature of their work, they have very special needs and it is suggested that at higher levels of management and especially under the levelling influence of the Public Service, these needs are not easily recognized nor responded to when uncovered. This is perhaps so in part because viable answers to potentially difficult problems are not available. There is a strong underlying theme brought to light for the author of this analysis that research programs in all their sophistication may be grossly misdirected, ignoring in their recommendations many of the subtle yet significant clues that can be gleaned from in-depth interviews and observations of and with operating controllers. The impression given when one compares published research and pseudo-research findings in this field with the often critical and caustic comments of the controllers is that a series of bad or faulty starts taken at the early stages of research into the stressful nature of the controllers environment have been pursued as if they had been landmarks in the research into the problem rather than the uncertain efforts that they often are. On some inaccurate assumptions and questionable research, the plight of the controller has in part been misconceived, misviewed and the resolution of the problem grossly mismanaged.

Study Summary

There appears to be general agreement in the research literature (32) that when an individual admits to inadquacy of sleep, there will be a tendency on his part to react uneconomically to external stress. Work performance often remains intact, which suggests that subjects have a capacity to cope with the anxiety causing situation

and this may possibly be a function of their span of energy. This suggests that under such circumstances, adaptation occurs at the behavioural level and at the level of physiological arousal (ref 33, 34) but there is serious potential for adverse effects as the subject is investing considerable effort to achieve a performance standard.

It is the main objective of this paper to demonstrate the probability that excessive physiologic cost expenditures occur in stressful environments and to test instruments allowing measurements relevant to this issue to be made in the actual working environment, with minimum job interference to the subject. The Air Traffic Services environment was selected first because it is assessed as being highly stressful, and second to encourage research effort over what has thus far been expended on Canadian ATS studies. The research model is designed in a manner that allows input sample substitution so the methods and instruments may be profitably employed in other stressful work environments.

The statistical analysis aspect of the study indicates that the independent ATS tower groups of CYYZ (N=14) and CYKZ (N=9) are too small and too highly variable to allow the making of predictive statements with any degree of certainty of the significance of any difference measured between these two groups or between each and the DCIEM comparison group.

In this study results confirm the utility, reliability and validity of the questionnaires and indicate even greater potential power when used with further sub-categorization of the sample on the basis of sleep adequacy, rather than on the basis of location of employment.

In addition to the questionnaires which were scored and analysed, there were three other sub-strategies tested that provided a basic dress rehearsal of the total systems research model of this study pertinent to the investigation of the effect that the external environment has on air traffic tower controllers. These sub-strategies are:

a. toxiological urinalysis screening,

b. continuous monitoring of electrical cardiac activity, and

c. behavioural observation - interview results.

The three ((a), (b) and (c)) sub-strategies were not intended to yield data of useable statistical nature for this preliminary study and did not allow analysis within the framework of this study.

But there is compelling evideince from the literature that each of these strategies may be a significant contributor factor in future research in that the urine screening for example suggest further sub-categorization of the sample into drug, and non-drug users, specifically in terms of mood-modifying substances. This would make possible investigation of the effects drug use has on a person's work performance, on their mood as measured by the Mood Scale with its deomonstrated consistency and reliability, or on other indicators of physiological cost, such as the ECG/QRS activity assessments. Urine screening satisfies a critical research parameter for future studies in that the presence of mood-modifying drugs is a confounding factor when measuring the effects that any alteration of the environment may have on levels of stress and levels of performance. The effect of the presence of mood-modifying drugs must be separated from the effects of external environmental change, and this strategy allows that by indicating the presence of such drugs.

The high cost, high technology ECG/QRS activity research strategy provides a method of determination of baseline QRS values which will be required at the commencement of any study involving the measurement of any effect that altering the environment may have on mental activity as compared to performance in the unaltered environment. Transit and terminal QRS scores would then become mental activity change indicators. Urine screening, another high cost, high technology strategy, would allow detection of the presence of mood-modifying drugs which if they were introduced at a mid-point of the long term study would invalidiate or at least alter data resulting in, at best, suspect findings.

Emerging from all of this is that, potentially, it may well be that the easily administered and very economical paper and pencil research methods do provide reasonably good indicators that parallel the physiological indicators. Once, and if, this is affirmed, it could well be that in the final research stage the expensive toxicological and bioelectrical methods could be eliminated in favour of the paper and pencil strategy of mood, general health and sleep quality assessments.

The behavioural observations and interviews are significant for future studies in that they provide a research instrument allowing both objective and subjective assessment of behavioural changes. A new and separate field of behavioural psychology has emerged and is based on the tremendous power and influence on behaviour of changing perceptions and expectations. One of the strongest methods of changing the internal state of the organism is to change its perception of an altered environment, in that if you change its perception of an altered environment, and the changes are imperceptable (sub-perception threshold), it may well

be that the subject perpetuates in assuming that things were as they have always been, and thus continues to function in its pre-change stressful way of responding in what should have become a non-stressful situation. By the same token, it is conceivable that the perception of an environment can be modified (without actually altering that environment) in such a manner that those in the situation will begin to function in a less stressful way, in response to an unchanged environment.

This may well be the most effective if not the only effective intervention method available in response to some stressful environments. Scientific investigation of the human response patterns in the ATS for example could be studied by graphic voice pattern analysis (sound spectrogram), and the measuring of job performance quality. Thus the behavioural assessment research strategies, both objective and subjective must be an integral part of any multi-strategy model concerned with physiological performance cost.

Future Research

This study established a research methodology possessing sufficient flexibility and integrity to cope with growth contingencies. On the basis of the findings a future research systems model evolved and is shown in Figure 2. With regards to the flexibility of the research design proposed, this study demonstrated the need to consider constantly the growth potential, and to apply a detailed feasibility analysis as follows:

1. Restraint analysis.

   Cost limitations and time contraints are factors the design must be able to absorb, since these may well appear when the program is fully active, but not yet completed.

2. Technological feasibility analysis.

   Methodology must be planned on the basis of current and developing states of the art in technology since the integrity of any research program is strongly dependent on available technology but must not be allowed to be limited by out-dated or less than fully developed technical research strategies or instruments.

3. Growth analysis.

   Growth potential must be designed into the system so that in case of available mid-program advanced tech-

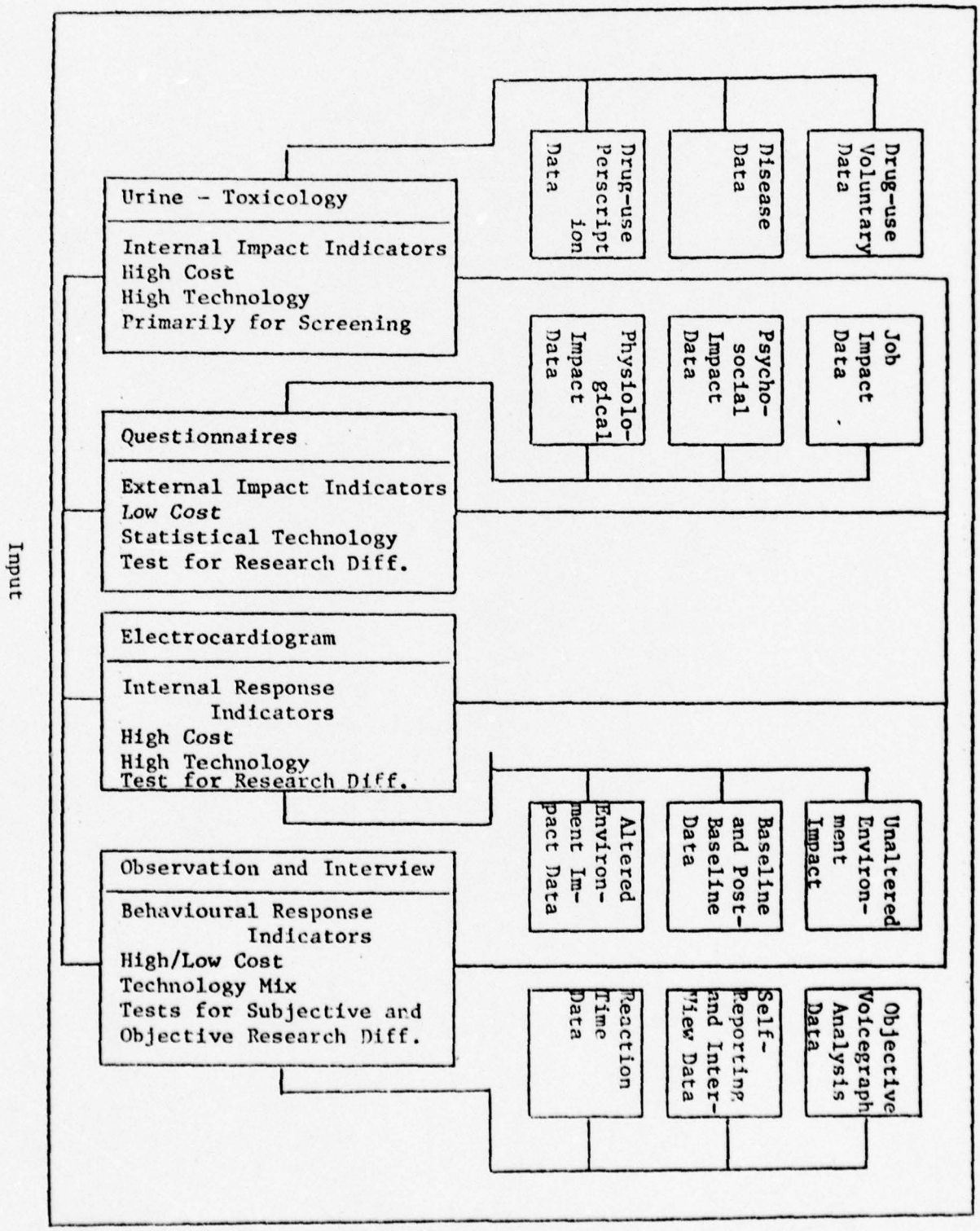
nology, no termination or costly re-design with associated time loss, results.

Real world factors often distort theoretically achieved design flows. Part of any planning process must be to prevent if possible or at least to minimize the impact of such occurrences.

FIGURE 3

RESEARCH SYSTEM DESIGN FOR SUBSEQUENT STUDIES OF

ATS AND OTHER STRESSFUL ENVIRONMENTS



APPENDIX A

METHOD FOR LIBRIUM AND VALIUM (CHLORDIAZEPOXIDE AND DIAZEPAM)

1. 1 ml Urine in 15 ml screw cap tube. Add 0.1 ml Con. HCl.

2. Place tube in oven at 100°C for 2 hours.

3. Cool tube and add 0.4 ml NH_4OH.

4. Add 3 ml Chloroform, shake for 15 mins. Centrifuge and transfer organic phase to another 15 ml conical tube.

5. Evaporate to dryness. Residue dissolved in 3 drops MeOH and apply to thin layer plate.

6. Develop plate in Benzene up to 10 cm.

7. Dry plate and spray with:

   Reagent #1. (2% freshly prepared Sodium Nitrite in 1N NCl), dry and spray with Reagent #2. (2% acqueous solution of N-1 Naphthylethylenediamine dihydrochloride).

INTERPRETATION.

Blue spot of Rf. .44 corresponding to ACB indicates usage of either of the benziodiazephine.

Yellow spot 1-Methyl-2 amino-5 chlorobenzopheno (MACE) at Rf. .70 before spraying any reagent, indicates very recent usage of diazepam.

Flurazapam gives a blue spot slightly higher than ACB.

10 ml dose of either diazepam/chlordiazepoxide will give positive reaction for ACB for 5 days.

Dr. B.M. Kaput
Director of Laboratories
Clinical Institute
Addiction Research Foundation

20 November, 1974

APPENDIX B

ANALYSIS PROGRAM - BIOELECTRIC MEASUREMENTS

Fabritek Command Language (FCL), is a conversational interpreter running into the PDP-9T computer. To the user, "SCORE" is one of more than twenty FCL commands available. This command allows the user to calculate the heart arrhythmia score from heart best interval data residing in the Fabritek (FTK) memory.

FORM:

> Score A T L C

or

> SCM A T L C

VARIABLES:

SC ; the command to score a single sample

SCM ; the command to score multiple samples

A_{10} ; a decimal number in the range Ø to 4095 specifying the sample starting address in the FTK

T_{10} ; a decimal number in the range 1 to 63 specifying the time interval in minutes for this sample

L_{10} ; a decimal number in the range 1 to 127 specifying the maximum heart rate deviation in beats per minute for purposes of calculating the heart rate coverage and the score

C_{10} ; an optional decimal number in the set of 1, 2, 4, 8 specifying the time compression of the interval data

DESCRIPTION

The SCORE command will calculate the average heart in beats per minute and the heart arrhythmia

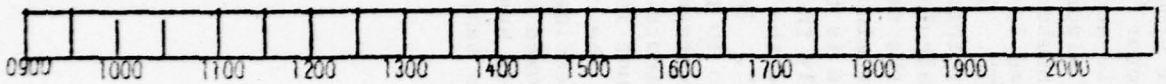
score for all heart beats that fall within the specified range limit "L". The sample size is determined by the "T" is minutes. It is assumed the beat interval data is recorded in milliseconds. If the analog data is converted at 2, 4, or 85 times real time, then a time compression factor "C: sllows the algorithm to account for this factor. The algorithm first determines the number of beat intervals required for a sample size of time "T". The average heart rate for this sample is initially calculated for all beats within the range of 40 to 200 beats per minute. A revised average rate is then computed rejecting only those beats that fall ouside the specified range limit "L". This process is iterated up to 10 times, or until sequential averages are within one beat per minute. The interval histogram count is printed following the SCORE. The number of beat intervals exceeding "L" is also printed, followed by the FTK address of the last beat interval comprising this sample.

APPENDIX C
SLEEP LOG - QUESTIONNAIRE

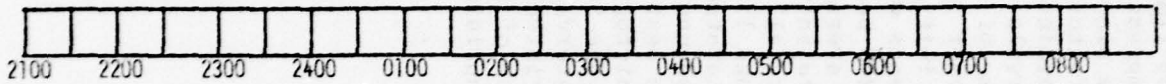
NAME

1. On the chart below draw a horizontal line through the squares corresponding to the half hour periods during which you were asleep during the last 24 hours. Put an X in the squares corresponding to any half hour period during which you recall waking up for 15 to 30 minutes.

DAYTIME



NIGHTTIME



2. How much trouble did you have going to sleep last night?

( ) NONE ( ) SLIGHT ( ) MODERATE ( ) CONSIDERABLE

Time to fall asleep _____ MINUTES

3. How many times do you recall waking up last night? _____

4. How rested do you feel?

( ) WELL RESTED ( ) MODERATELY RESTED ( ) SLIGHTLY RESTED ( ) NOT AT ALL

5. Do you feel that you could have used more sleep? ( ) YES ( ) NO

6. Today's Mood

( ) VERY POOR ( ) POOR ( ) AVERAGE ( ) GOOD

Number of dreams recalled

REMARKS (Note especially reasons for loss of sleep, such as duty, noise, cold, personal, etc.

SLEEP LOG

8. Choose one of the seven statements below which best describes your present feelings. How you feel right now.

(1) Feeling active and vital; alert, wide awake.

(2) Functioning at a high level, but not at peak; able to concentrate

(3) Relaxed; awake, responsive, but not at full alertness.

(4) A little foggy; let down; not at peak.

(5) Foggy; slowed down; beginning to lose interest in remaining awake.

(6) Sleepy; woozy; prefer to be lying down; fighting sleep.

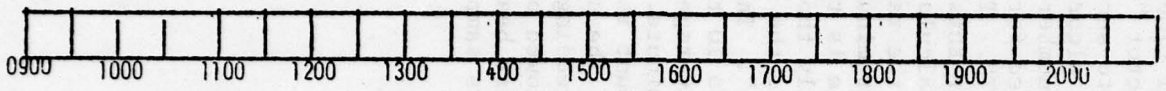
(7) Almost in Reverie; sleep onset soon; losing struggle to remain awake.

APPENDIX C
SLEEP LOG - QUESTIONNAIRE

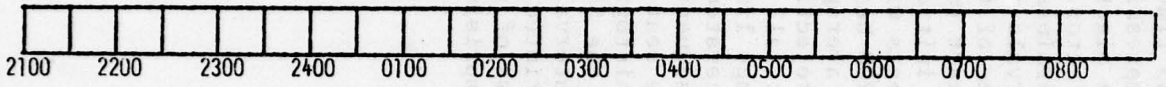
NAME

1. On the chart below draw a horizontal line through the squares corresponding to the half hour periods during which you were asleep during the last 24 hours. Put an X in the squares corresponding to any half hour period during which you recall waking up for 15 to 30 minutes.

DAYTIME



NIGHTTIME



2. How much trouble did you have going to sleep last night?

( ) NONE ( ) SLIGHT ( ) MODERATE ( ) CONSIDERABLE

Time to fall asleep _____ MINUTES

3. How many times do you recall waking up last night? _____

4. How rested do you feel?

( ) WELL RESTED ( ) MODERATELY RESTED ( ) SLIGHTLY RESTED ( ) NOT AT ALL

5. Do you feel that you could have used more sleep? ( ) YES ( ) NO

6. Today's Mood

( ) VERY POOR ( ) POOR ( ) AVERAGE ( ) GOOD

Number of dreams recalled

REMARKS (Note especially reasons for loss of sleep, such as duty, noise, cold, personal, etc.

SLEEP LOG

8. Choose one of the seven statements below which best describes your present feelings. How you feel right now.

(1) Feeling active and vital; alert, wide awake.

(2) Functioning at a high level, but not at peak; able to concentrate

(3) Relaxed; awake, responsive, but not at full alertness.

(4) A little foggy; let down; not at peak.

(5) Foggy; slowed down; beginning to lose interest in remaining awake.

(6) Sleepy; woozy; prefer to be lying down; fighting sleep.

(7) Almost in Reverie; sleep onset soon; losing struggle to remain awake.

APPENDIX D

MOOD SCALE - QUESTIONNAIRE

Instructions: For each item, choose one of the four answers that best describes how you feel <u>now</u>. Then put an "X" in that box.

NAME						AGE	SEX	DATE	
	NOT AT ALL	A LITTLE	QUITE A BIT	EXTREMELY		NOT AT ALL	A LITTLE	QUITE A BIT	EXTREMELY
ACTIVE					GOOD-NATURED				
ALERT					GROUCHY				
ANNOYED					HAPPY				
CAREFREE					JITTERY				
CHEERFUL					KIND				
ABLE TO CONCENTRATE					LIVELY				
CONSIDERATE					PLEASANT				
DEFIANT					RELAXED				
DEPENDABLE					SATISFIED				
DROWSY					SLEEPY				
DULL					SLUGGISH				
EFFICIENT					TENSE				
FRIENDLY					ABLE TO THINK CLEARLY				
FULL OF PEP					TIRED				
					ABLE TO WORK HARD				

APPENDIX E

GOLDBERG GENERAL HEALTH QUESTIONNAIRE

30 ITEM U.S. SCALE

IN THE PAST MONTH HAVE YOU:

1. - been able to concentrate on whatever you're doing?

better than usual	same as usual	less than usual	much less than usual

2. - lost much sleep over worry?

not at all	no more than usual	rather more than usual	much more than usual

3. - been feeling mentally alert and wide awake?

better than usual	same as usual	less alert than usual	much less alert

4. - been feeling full of energy?

better than usual	same as usual	less energy than usual	much less energetic

5. - been having restless, disturbed nights?

not at all	no more than usual	rather more than usual	much more than usual

6. - been managing to keep yourself busy and occupied?

more so than usual	same as usual	rather less than usual	much less than usual

7. - been getting out of the house as much as usual?

more than usual	same as usual	less than usual	much less than usual

8. - been managing as well as most people would in your place?

better than most	about the same	rather less well	much less well

9. - felt on the whole you were doing things well?

better than usual	about the same	less well than usual	much less well

10. - been able to feel warmth and affection for those near to you?

better than usual	about same as usual	less well than usual	much less well

HAVE YOU RECENTLY:

11. - been finding it easy to get on with other people?

better than usual	about same as usual	less well than usual	much less well

12. - felt that you are playing a useful part in things?

more so than usual	same as usual	less useful than usual	much less useful

13. - felt capable of making decisions about things?

more so than usual	same as usual	less so than usual	much less capable

14. - felt constantly under strain?

not at all	no more than usual	rather more than usual	much more than usual

15. - felt you couldn't overcome your difficulties?

not at all	no more than usual	rather more than usual	much more than usual

16. - been finding life a struggle all the time?

not at all	no more than usual	rather more than usual	much more than usual

17. - been able to enjoy your normal day-to-day activities?

more so than usual	same as usual	less so than usual	much less than usual

18. - been taking things hard?

not at all	no more than usual	rather more than usual	much more than usual

19. - been getting scared or panicky for no good reason?

not at all	no more than usual	rather more than usual	much more than usual

20. - been able to face up to your problems?

more so than usual	same as usual	less able than usual	much less able

21. - found everything too much for you?

not at all	no more than usual	rather more than usual	much more than usual

22. - been feeling unhappy and depressed?

not at all	no more than usual	rather more than usual	much more than usual

23. - been losing confidence in yourself?

not at all	no more than usual	rather more than usual	much more than usual

24. - been thinking of yourself as a worthless person?

not at all	no more than usual	rather more than usual	much more than usual

25. - felt that life is entirely hopeless?

not at all	no more than usual	rather more than usual	much more than usual

26. - been feeling hopeful about your own future?

more so than usual	about same as usual	less so than usual	much less hopeful

27. - been feeling reasonably happy, all things considered?

more so than usual	about same as usual	less so than usual	much less than usual

28. - been feeling nervous and strung-up?

not at all	no more than usual	rather more than usual	much more than usual

29. - felt that life isn't worth living?

not at all	no more than usual	rather more than usual	much more than usual

30. - found that you couldn't do anything because your nerves were too bad?

not at all	no more than usual	rather more than usual	much more than usual

APPENDIX F

PERSONAL INFORMATION QUESTIONNAIRE
1975 - ATS - 1976

Please answer the following questions by circling one response or filling in the blank space. There are no trick or right or wrong answers, so please respond the way you really feel. Complete confidentiality is assured once the form has been completed. Information will not be used in any manner that allows identification, and is requested in support of a study concerning physiological cost determination during continuous activity.

Your participation and support are sincerely appreciated.

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1. Name: 2. Sex: Male/Female

3. Age:

4. Marital Status: Single Married Other*

   Separated Divorced

   * (if "other", please elaborate)

5. Any children:

6. Education:

7. How long have you been associated as an Air Traffic Controller:

   1 - 5 years 6 - 10 years 10 - 15 years

   16 - 20 years 20 - 25 years 26 - up

8. How did you become interested in ATS?

9. Did you have any previous occupation?

   (if affirmative, please elaborate).

10. Are you satisfied and happy with the actual job activity?

    (would you rather fight than switch).

11. Are you a pilot? (Do you hold a valid pilot license?)

12. Are you receiving pilot training? (Do you hold a valid student pilot permit?)

13. Would you like to become a pilot?

14. Is flying your "first love"?

15. In your own estimation how do you consider your stress tolerance?

    Low Average Above average High

    (stress is any external event that causes a reaction of displeasure or anxiety in you)

16. Do you have a "code of ethics" by which you live?

    (any of the ten commandments or any non-religious standard to which you have decided you must conform - please elaborate).

17. Are there ATS facilities that have an "Elite Status" among all?

    (if it makes you feel more comfortable, use the U.S. facilities as an example).

18. If your answer to 17 is affirmative, would you state how "Elite Status" is achieved.

19. In selecting your place of residence, would you make your choice on the basis of:

    a. the class of people living in that neighbourhood

    b. the type of dwelling

    c. availability of resources (shopping plazas, parks, etc.)

    d. other (please elaborate)

20. What sports are you actively participating in?

21. What are your hobbies?

22. In your estimation, what kind of person has promising ATC potential. (consider character, personality, education, desire, age limits, attitude towards life, etc.)

23. Is there anything you would like to say with regard to the questions asked or subject omitted? Please take your time in answering. It may be a thought about yourself, your work or your friends.

APPENDIX G

PERSONAL INTERVIEW FORMAT

Guide lines used in personal interviewing of ATS personnel. The information requirements are specific to this study only.

1. Concerning the internal tower environment;

   a. how do you feel about the colour schemes

   b. does working your position in sunlight affect you differently to when it is in the shade, and what is your preference

   c. does the tower design, and the equipment layout, please you professionally

   d. do visits to the Tower by individuals or groups distract you

2. Concerning the external tower environment;

   a. is parking lot accessibility good

   b. are refreshment and food faciliities satisfactory

   c. is there an area allowing you to relax or do you feel you need such a place

   d. are washroom facilities readily available and adequate

3. Concerning your peer associations during duty; (question to males).

   a. do you prefer an all male to a mixed male/female group

   b. does the presence of a female inhibit you in any way

   c. do you release professional frustrations in the presence of a female or do you delay reactions

   d. do you actually prefer the presence of a female controller

4. Concerning your associations during duty (questions to females);

   a. does being a minority bother you in this professional setting

b. are you aware of any effect you cause in your male peers

c. would you welcome a protective attitude towards you

d. do you allow strongly directed feelings non-professional in nature, and do these interfere with your work

5. Concerning territoriality of your operating position;

a. do you feel strongly protective of your position

b. do you allow interference and if so, to what extent

c. does your position become a strongly private place

d. does stress in any way affect your attitude towards positional territoriality

6. Concerning flying interests:

a. are you now a pilot

b. how far back did you desire to fly

c. what interferred with your flying aspirations

d. would you rather fly than do your present job

7. Concerning your attitude towards those who fly;

a. do you feel antagonistic towards pilots

b. in your duties, do you control aircraft (impersonal) or do you control pilots (personal)

c. are you superior to a pilot professionally

d. does a pilot have your respect or do you feel more like his servant

8. Concerning your employment in ATS;

a. is job isolation (perhaps through the use of a head set) important to you

b. is working space a factor, in that you would prefer

compactness through positional isolation (not unlike an aircraft cockpit)

c. would employment in the centre (a large space) be attractive to you

d. is direct supervision objectionable to you

9. Concerning the making of professional errors:

a. does it change the significance if others are present (bothers you much more or much less)

b. does it change the significance of the error, if others are aware of it

c. do you expect or desire you peers to intervene

d. does having made an incorrect professional decision bother you for a long time

10. Concerning external recreational activities:

a. you participate in any high risk activity (parachuting, hang gliding, car racing, etc.)

b. are your sports activities indoors or outdoors oriented

c. do you prefer team sports

d. does isolated camping in "unspoiled" nature appeal to you profoundly

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